Exhibit D

Part 2

Noise Covariance Matrices

- The patent contains and uses an ***express definition for "Noise Covariance Matrices***"
  - The inventors' express definition controls, *Phillips v. AWH Corp.*, 415 F.3d 1303, 1316 (Fed. Cir. 2005) (en banc).
  - Several courts, including the Federal Circuit, have found that "i.e." defines a term absent an alternative definition in the intrinsic evidence

'839 Patent

A block diagram of a CS-MLSD detector circuit **28** is shown in FIG. **2**. The CS-MLSD detector circuit **28** is a part of the detector circuit **26** of FIG. **1**. The detector circuit **28** has a feedback circuit **32** which feeds back into a Viterbi-like detector **30**. The outputs of the detector **30** are decisions and delayed signal samples, which are used by the feedback circuit **32**. A noise statistics tracker circuit **34** uses the delayed samples and detector decisions to update the noise statistics, i.e., to update the noise covariance matrices. A metric computation update circuit **36** uses the updated statistics to calculate the branch metrics needed in the Viterbi-like algorithm. The algorithm does not require

The signal sample is delayed at step **42**. The past samples and detector decisions are used to update the noise statistics at step **44**. Branch metrics, which are used in the sequence detection step **38**, are calculated at step **46**.

'839 Patent at cols. 3:30-41; 11:16-19.

Noise Covariance Matrices

- *Marvell's reliance on Pfizer, Inc. v. Teva Pharmaceuticals, Inc.*, 429 F.3d 1364 (Fed. Cir. 2005) is misplaced

  - The patent in *Pfizer* (US 4,743,450) contained a second express definition for the claim term "saccharides"

United States Patent [19] — [11] **Patent Number: 4,743,450**
Harris et al. — [45] **Date of Patent: May 10, 1988**

(b) stabilizers which contain alkaline agents alone or alkaline agents in combination with saccharides (i.e., sugars) as one or more cyclization, hydrolysis, and discoloration inhibitor(s).

SACCHARIDES

The saccharide components to be used in the pharmaceutical products and methods of the invention are substances which are compatible with the alkali or alkaline earth metal-containing stabilizers. Generally, they are substances which do not contain groups which could significantly interfere with the function of either the metal-containing component or the drug component. Mannitol, lactose, and other sugars are preferred. Mixtures are operable.

'450 Patent at cols. 1:60-63, 3:45-55

Noise Covariance Matrices

- Marvell's reliance on *Pfizer, Inc. v. Teva Pharmaceuticals, Inc.*, 429 F.3d 1364 (Fed. Cir. 2005) is misplaced

  - There is ***no second, alternate express definition of "noise covariance matrices" in the CMU patents***
  - The inventors' lexicography controls and the court should decline Marvell's invitation to construe this term without regard to the inventors' definition

Noise Covariance Matrices

- Marvell's extrinsic evidence supports CMU's proposed construction
  - "i.e." is contrasted with "e.g." – the latter ***"introduces one or more examples that illustrate something stated directly…before it"***
  - The specification uses "i.e." not "e.g."
  - The Federal Circuit has held that "i.e." is definitional
    Opening Claim Construction Brief at pg. 29.

i.e., e.g. Usage books note that these two abbreviations tend to be confused with each other. Our evidence shows that the usual error is the use of *i.e.* in place of *e.g.* The error is relatively rare in edited material, but it does seem to occur widely in speech and casual writing. To avoid it, remember that *i.e.* is an abbreviation for the Latin *id est* and means "that is"; *e.g.* is an abbreviation of *exempli gratia* and means "for example." *I.e.*, like *that is*, typically introduces a rewording or clarification of a statement that has just been made or of a word that has just been used:

> Most of the new books are sold through 3,500 Christian (i.e., Protestant) bookstores —*N.Y. Times Book Rev.*, 31 Oct. 1976

> It is money that wasn't absorbed by government, i.e. the administration tax cuts, that is spurring current growth —Joe Sneed & John Tatlock, *Houston Post*, 31 Aug. 1984

E.g. introduces one or more examples that illustrate something stated directly or shortly before it:

> Poets whose lack of these isn't made up by an inescapable intensity of personal presence (e.g. Sylvia Plath) simply aren't represented —Hugh Kenner, *N.Y. Times Book Rev.*, 17 Oct. 1976

> . . . rent them to responsible tenants, e.g., retired naval officers —David Schoenbaum, *N.Y. Times*, 3 July 1977

If you feel uncertain about which abbreviation is called for in a particular context, try substituting *that is* or *for example*, or else revise the sentence so that neither is required.

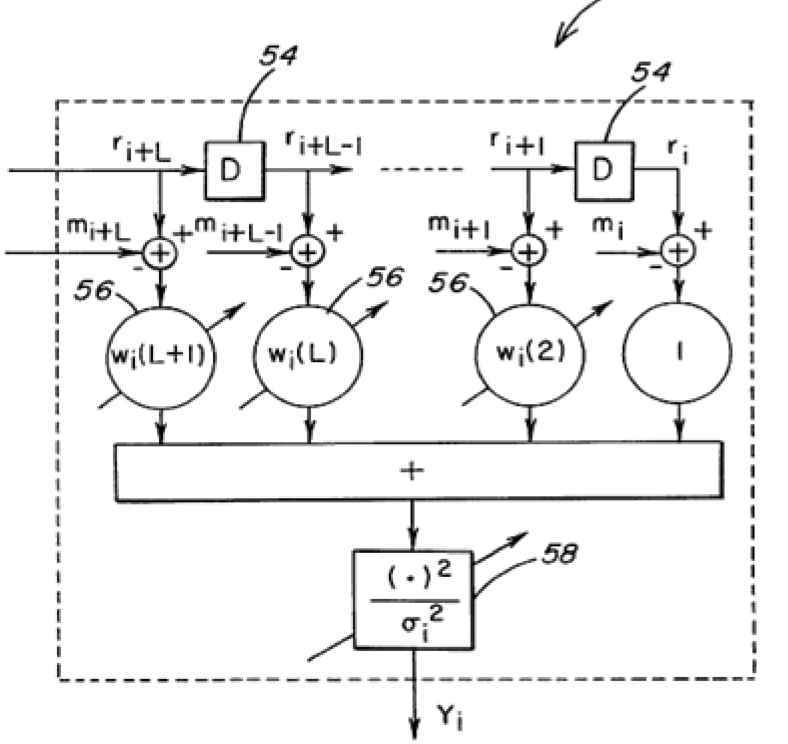
Lehav Declaration for Surreply, 3/11/10, Ex. 1, pg. 4.

Noise Covariance Matrices

- The intrinsic evidence describes embodiments for calculating "correlation-sensitive branch metrics" that use "noise covariance matrices" without using Marvell's asserted "matrix"
  - Figs. 3A and 3B do not need to use Marvell's "matrix"
  - Equation 23 from the '180 Patent can be used to calculate the variance without using Marvell's matrix.

'839 Patent

FIG. 3B



'839 Patent, Fig. 3B

Noise Covariance Matrices

- Dr. McLaughlin's unrebutted second declaration shows that equation 23 of the patents can compute the variance (σ^2) without Marvell's required "expected value"

> 9. The CMU patents identify techniques for computing the variance (σ^2) without computing a correlation value and without using a covariance matrix according to Marvell's constructions (which proposed constructions require the use of an expected value computation in the form of the equation E[*XY*], where E is the expected value and *X* and *Y* are the separate random variables). For example, equation (23) of the CMU patents (*see* '839 patent at col. 10:14) shows how to determine the variance (σ^2) without computing a correlation value and without using a covariance matrix according to Marvell's constructions. In addition, the CMU

McLaughlin Second Declaration, 3/4/10, at pg. 2.

Noise Covariance Matrices

- Marvell's assertion that CMU's construction covers "***any*** noise statistics" is based on improperly truncating CMU's complete proposed construction

CMU's PROPOSED CONSTRUCTION
"Noise covariance matrices" means "noise statistics used to calculate the 'correlation-sensitive branch metrics.'"

'839 Patent at 2:15-20; 2:43-47; 3:30-44; col. 5:48-55; col. 6:36-col. 8:27; col. 9:21-39; Figs. 3A-3B.

- The "noise statistics" of CMU's construction are only those noise statistics that can be used to "calculate the correlation sensitive branch metrics"

Noise Covariance Matrices

- It is ***impossible*** to "calculate correlation sensitive branch metrics" with Euclidian branch metric function

'839 Patent

Euclidian branch metric. In the simplest case, the noise samples are realizations of independent identically distributed Gaussian random variables with zero mean and variance σ^2. This is a white Gaussian noise assumption. This implies that the correlation distance is L=0 and that the noise pdf s have the same form for all noise samples. The total ISI length is assumed to be $K=K_l+K_t+1$, where K_l and K_t are the leading and trailing ISI lengths, respectively. The conditional signal pdfs are factored as

'839 Patent at col. 5:59-67.

Noise Covariance Matrices

- Marvel's reliance on ***<u>Intamin</u>*** is misplaced
  - All of the embodiments of the CMU patents for adapting the noise statistics are described in terms of "noise covariance matrices"
    - Figs. 3A and 3B are linked to Fig. 13
    - The noise statistics, which can be determined in different ways as described at col. 8 of the '839 Patent, are used by the circuits of Fig. 3A and 3B
  - Some of the claims do not require updating "noise covariance matrices"
    - See e.g., claims 27-28 of the '839 Patent
    - Not all of the claims read on the "noise covariance matrices" embodiments, but the "noise covariance matrices" claims read on the different ways of adapting the noise statistics

Noise Covariance Matrices

- Marvell's reference to claims 20, 21 and 26 of the '839 Patent is irrelevant
  - Marvell is ***conflating the circuits used to compute the correlation sensitive branch metrics with the data that is used by those circuits*** – e.g. the "noise statistics"
  - None of the claims that require "noise covariance matrices" call out a specific form of "branch metric computation circuit"

'839 Patent

20. A branch metric computation circuit for generating a branch weight for branches of a trellis for a Viterbi-like detector, wherein the detector is used in a system having Gaussian noise, comprising:

a logarithmic circuit having for each branch an input responsive to a branch address and an output;

a plurality of arithmetic circuits each having a first input responsive to a plurality of signal samples, a second input responsive to a plurality of target response values, and an output, wherein each of the arithmetic circuits corresponds to each of the branches;

a sum circuit having for each branch a first input responsive to said output of said logarithmic circuit, a second input responsive to said output of said arithmetic circuit, and an output.

21. The circuit of claim **20** wherein said branch metric computation circuit is a tapped-delay line circuit with adaptive weight.

'839 Patent at col. 16:1-19.

Noise Covariance Matrices

- CMU's construction does not include the "mean signal values"
  - Marvell's reliance on col. 8:24-27 proves CMU's point
  - The term used in Marvell's citation is "signal statistics" not "noise statistics"
    - The specification makes clear that the phrase signal statistics includes more than the "covariance matrices" – also includes the "mean signal values" (the "target" or "ideal" values from the technology tutorial)

'839 Patent

> Computing the branch metrics in (10) or (13) requires knowledge of the signal statistics. These statistics are the mean signal values m_i in (12) as well as the covariance matrices C_i in (13). In magnetic recording systems, these

'839 Patent at col. 8:24-27.

> circuit 32. A noise statistics tracker circuit **34** uses the delayed samples and detector decisions to update the noise statistics, i.e., to update the noise covariance matrices. A

'839 Patent at col. 3:36-38.

Noise Covariance Matrices

- In light of –
  - The express definition of "noise covariance matrices" in the patent
  - Marvell's acknowledgement that the patent discloses methods of computing the correlation sensitive branch metrics ***<u>without</u>*** computing a "correlation" or using a "covariance matrix" per Marvell's construction
- There is no basis to exclude any of the disclosed embodiments for adapting the noise statistics from the coverage of the "noise covariance matrices" claims

The "Signal-Dependent" Terms

- *Signal-Dependent Noise*
- *Signal-Dependent Branch Metric Function*

“Signal-Dependent” Terms

DISPUTED CLAIM TERMS

Signal-Dependant Noise

’839 Patent Claims 2, 5 & ’180 Patent Claim 1

CMU’s PROPOSED CONSTRUCTION	MARVELL’s PROPOSED CONSTRUCTION
“Signal-dependent noise” means “media noise in the readback signal whose noise structure is attributable to a specific sequence of symbols (*e.g.*, written symbols).”	**“Signal-dependent noise” means “noise that is dependent on the signal.”**

’839 Patent at col. 1:38-51; col. 2:9-20; col. 4:24-27; col. 5:48-54; col. 10:18-19.

’839 Patent, at 2:18-20; 4:24-27; 5:45-55; 6:35-39; cls. 2, 5; ’180 Patent, cl. 1. ’839 File History, March 10, 2000 Office Action and Response thereto.

“Signal-Dependent” Terms

DISPUTED CLAIM TERMS

Signal-Dependant Branch Metric Function

’839 Patent Claims 3, 4 & ’180 Patent Claim 2

CMU’s PROPOSED CONSTRUCTION	MARVELL’s PROPOSED CONSTRUCTION
“Signal-dependent branch metric function” means “a ‘branch metric function’ that accounts for the signal-dependent structure of the media noise.”	**“Signal-dependent branch metric function” means “a ‘branch metric function’ that accounts for ‘signal-dependent noise.’”**
’839 Patent at col. 1:38-51; col. 2:9-20; col. 5:48-55; col. 6:14 to col. 7:60.	’839 Patent at 5:48-55; cls. 3, 4; ’180 Patent at ’180 cl. 2; ’839 File History, March 10, 2000 Office Action and Response thereto.

“Signal-Dependent” Terms

- Why construing these terms matters
  - Marvell’s construction appears to be aimed at supporting its invalidity contentions by allowing Marvell to reference prior art that does not take into account the pattern recorded on the media

“Signal-Dependent” Terms

- The “signal-dependent” claim terms appear in asserted claims and 2, 3, 4, and 5 of ’839 Patent and asserted claims 1 and 2 of the ’180 Patent
  - Claims 1 and 2 of the ’180 Patent are representative

’180 Patent

1. A method of determining branch metric values in a detector, comprising:

receiving a plurality of time variant signal samples, the signal samples having one of signal-dependent noise, correlated noise, and both signal dependent and correlated noise associated therewith;

selecting a branch metric function at a certain time index; and

applying the selected function to the signal samples to determine the metric values.

2. The method of claim 1, wherein the branch metric function is selected from a set of signal-dependent branch metric functions.

’180 Patent at col. 15:39-51.

“Signal-Dependent” Terms

- CMU’s construction comes directly from a description of “the invention” found at the beginning of the ’839 Patent
  - The Federal Circuit has repeatedly used statements concerning “the invention” from the Summary of the Invention to construe claim terms

See, e.g. Microsoft Corp. v. Multi-Tech Sys., 357 F.3d 1340, 1348 (Fed. Cir. 2004).

’839 Patent

SUMMARY OF THE INVENTION

In high density magnetic recording, noise samples corresponding to adjacent signal samples are heavily correlated as a result of front-end equalizers, media noise, and signal nonlinearities combined with nonlinear filters to cancel them. This correlation deteriorates significantly the performance of detectors at high densities.

The trellis/tree branch metric computation of the present invention is correlation-sensitive, being both signal-dependent and sensitive to correlations between noise samples. This method is termed the correlation-sensitive maximum likelihood sequence detector (CS-MLSD), or simply correlation-sensitive sequence detector (CS-SD).

Because the noise statistics are non-stationary, the noise sensitive branch metrics are adaptively computed by estimating the noise covariance matrices from the read-back data. These covariance matrices are different for each branch of the tree/trellis due to the signal dependent structure of the media noise. Because the channel characteristics in magnetic recording vary from track to track, these matrices are tracked on-the-fly, recursively using past samples and previously made detector decisions.

’839 Patent at col. 2:1-23.

“Signal-Dependent” Terms

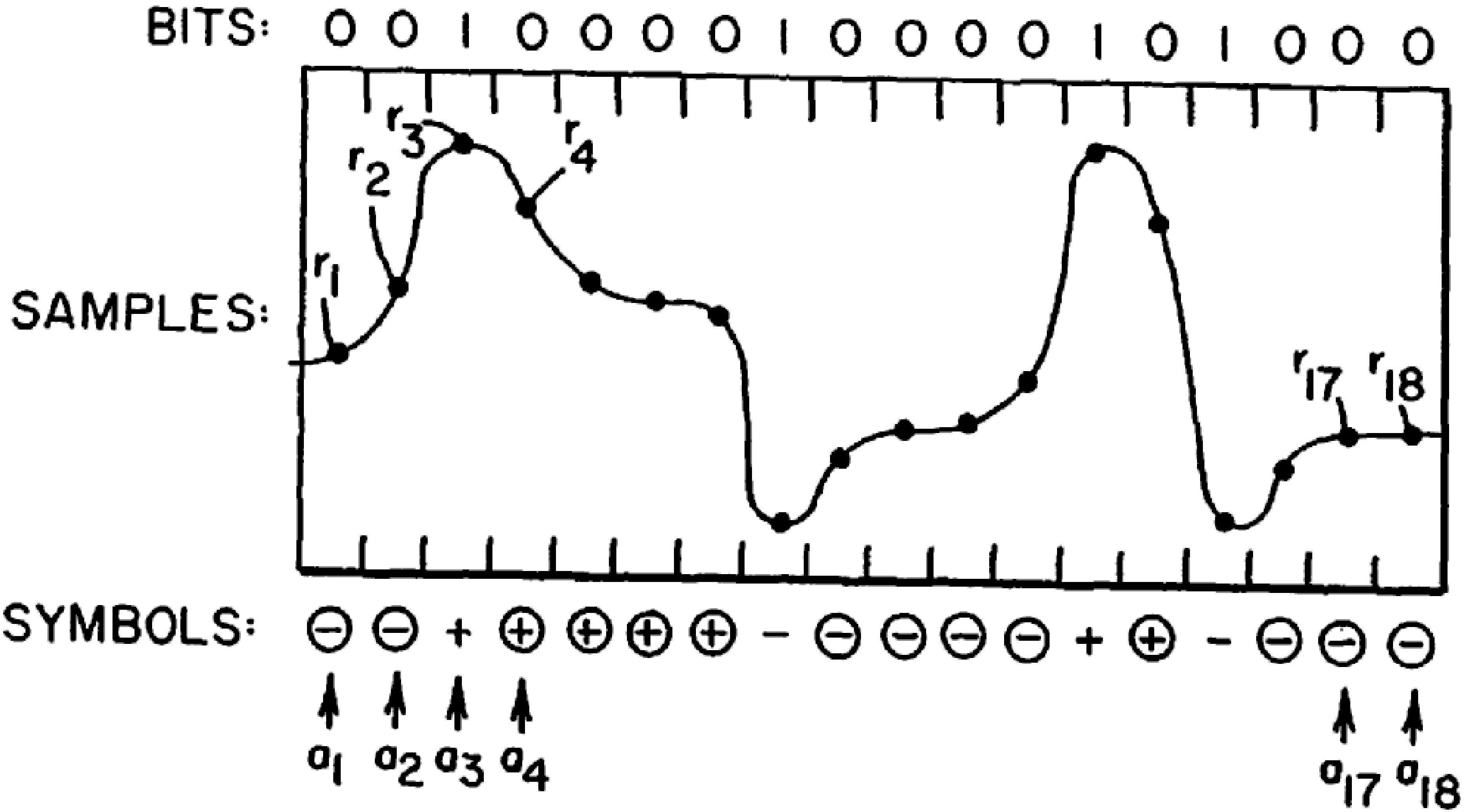
- The intrinsic evidence supports CMU’s construction. All citations describe the term “signal-dependent” in relation to the specific sequence of symbols written on the disk

’839 Patent

> Due to the signal dependent nature of media noise in magnetic recording, the functional form of joint conditional pdf f $(r_1, \ldots, r_N|a_1, \ldots, a_N)$ in (1) is different for different symbol sequences $a_1, \ldots, a_N$. Rather than making this

’839 Patent at col. 4:24-27.

FIG. 3


BITS: 0 0 1 0 0 0 0 1 0 0 0 0 1 0 1 0 0 0
SAMPLES:
r1
r2
r3
r4
r17
r18
SYMBOLS: ⊖ ⊖ + ⊕ ⊕ ⊕ ⊕ − ⊖ ⊖ ⊖ ⊖ + ⊕ − ⊖ ⊖ ⊖
a1
a2
a3
a4
a17
a18

“Signal-Dependent” Terms

- The intrinsic evidence supports CMU’s construction. All citations describe the term “signal-dependent” in relation to the specific sequence of symbols written on the disk.

’839 Patent

> M_i represents the branch metric of the trellis/tree in the Viterbi-like algorithm. The metric is a function of the observed samples $r_i, r_{i+1}, \ldots, r_{i+L}$. It is also dependent on the postulated sequence of written symbols $a_i - K_1, \ldots, a_i + L + K_t$, which ensures the signal-dependence of the detector. As a consequence, the branch metrics for every branch

’839 Patent at col. 5:48-52.

“Signal-Dependent” Terms

- Marvell argues that the CMU patent specifications are not limited to magnetic recording channels; therefore, it is improper to define “signal-dependent” in a way that is limited to media noise, since media noise is practically limited to magnetic recording
- Marvell is wrong because:
  - The CMU patents clearly define “signal-dependent” in terms of a pattern (or sequence) of symbols written to the disk
  - Marvell acknowledges that “signal-dependent” is equivalent to “data dependent”
  - Other claims of the CMU patent are not limited to magnetic recording channels or “signal-dependent”
    - See e.g., claims 1,6-10, 20-22, and 27-28 of the ’839 Patent

shows the performance of the PR4 detectors at this density FIG. 9 is similar to FIG. 7, except that the error rates have increased. This is again due to a mismatch between the original signal and the PR4 target response, which is why the PR4 shaping filter introduces correlation in the noise. PR4(C2) still outperforms the two other algorithms, showing the value of exploiting the correlation across signal samples.

FIG. 10 shows the error rates obtained when using the EPR4 detectors. Due to a higher density, the media noise is higher than in the previous example with symbol separations of 4.4a. This is why the graph in FIG. 10 has moved to the right by 2 dB in comparison to the graph in FIG. 8. While the required S(AWG)NR increased, the margin between the EPR4(Euc) and EPR4(C2) also increased from about 0.5 dB to about 1 dB, suggesting that the correlation-sensitive metric is more resilient to density increase. This is illustrated in FIG. 11 where the S(AWG)NR required for an error rate of 10^{-5} is plotted versus the linear density for the three EPR4 detectors. From FIG. 11 it can be seen that, for example with an S(AWG)NR of 15 dB, the EPR(Euc) detector operates at a linear density of about 2.2 symbols/PW50 and the EPR4(C2) detector operates at 2.4 symbols/PW50, thus achieving a gain of about 10% of linear density.

Symbol separation of 2.9a. This recording density corresponds to a symbol density of 3 symbols/PW50. Due to a very low number of symbols per a, this is the density where the detectors significantly lose performance due to the percolation of magnetic domains, also referred to as nonlinear amplitude loss or partial signal erasure. FIGS. 12 and 13 show the performance of the PR4 and EPR4 families of detectors at this density. The detectors with the C2 metric outperform the other two metrics. The error rates are quite high in all cases. This is because at the symbol separation of 2.9a, nonlinear effects, such as partial erasure due to percolation of domains, start to dominate. These effects can only be undone with a nonlinear pulse shaping filter, which have not been employed here.

The experimental evidence shows that the correlation sensitive sequence detector outperforms the correlation insensitive detectors. It has also been demonstrated that the performance margin between the correlation sensitive and the correlation insensitive detectors grows with the recording density. In other words, the performance of the correlation insensitive detector deteriorates faster than the performance of the correlation sensitive detector. Quantitatively, this margin depends on the amount of correlation in the noise passed through the system. Qualitatively, the higher the correlation between the noise samples, the greater will be the margin between the CS-SD and its correlation insensitive counter part.

While the present invention has been described in conjunction with preferred embodiments thereof, many modifications and variations will be apparent to those of ordinary skill in the art. For example, the present invention may be used to detect a sequence that exploits the correlation between adjacent signal samples for adaptively detecting a sequence of symbols through a communications channel. The foregoing description and the following claims are intended to cover all such modifications and variations.

What is claimed is:

1. A method of determining branch metric values for branches of a trellis for a Virterbi-like detector, comprising:

selecting a branch metric function for each of the branches at a certain time index; and

applying each of said selected functions to a plurality of signal samples to determine the metric value corresponding to the branch for which the applied branch metric function was selected, wherein each sample corresponds to a different sampling time instant.

2. The method of claim 1 further comprising the step of receiving said signal samples, said signal samples having signal-dependent noise, correlated noise, or both signal-dependent and correlated noise associated therewith.

3. The method of claim 1 wherein said branch metric functions for each of the branches are selected from a set of signal-dependent branch metric functions.

4. A method of determining branch metric values for branches of a trellis for a Viterbi-like detector, comprising:

selecting a branch metric function for each of the branches at a certain time index from a set of signal-dependent branch metric functions; and

applying each of said selected functions to a plurality of signal samples to determine the metric value corresponding to the branch for which the applied branch metric function was selected, wherein each sample corresponds to a different sampling time instant.

1. A method of determining branch metric values for branches of a trellis for a Virterbi-like detector, comprising:
selecting a branch metric function for each of the branches at a certain time index; and
applying each of said selected functions to a plurality of signal samples to determine the metric value corresponding to the branch for which the applied branch

metric function was selected, wherein each sample corresponds to a different sampling time instant.
2. The method of claim 1 further comprising the step of receiving said signal samples, said signal samples having signal-dependent noise, correlated noise, or both signal-dependent and correlated noise associated therewith.
3. The method of claim 1 wherein said branch metric functions for each of the branches are selected from a set of signal-dependent branch metric functions.
4. A method of determining branch metric values for branches of a trellis for a Viterbi-like detector, comprising:
selecting a branch metric function for each of the branches at a certain time index from a set of signal-dependent branch metric functions; and
applying each of said selected functions to a plurality of signal samples to determine the metric value corresponding to the branch for which the applied branch metric function was selected, wherein each sample corresponds to a different sampling time instant.

5. The method of claim 4 further comprising the step of receiving said signal samples, said signal samples having signal-dependent noise, correlated noise, or both signal-dependent and correlated noise associated therewith.

6. A method of generating a signal-dependent branch weight for branches of a trellis for a Viterbi-like detector, comprising:

selecting a plurality of signal samples, wherein each sample corresponds to a different sampling time instant;

calculating a first value representing a branch-dependent joint probability density function of a subset of said signal samples;

calculating a second value representing a branch dependent joint probability density function of said signal samples;

calculating the branch weight from said first and second values; and

outputting the branch weight.

7. The method of claim 6 further comprising the step of correcting the branch weight by an additive term.

8. The method of claim 6 further comprising the step of correcting the branch weight by a multiplicative term.

9. The method of claim 7 wherein said correcting step includes the step of selecting a third value representing a prior branch probability for use as said additive term.

10. A method of generating a branch weight for branches of a trellis for a Viterbi-like detector, wherein the detector is used in a system having Gaussian noise, comprising:

selecting a plurality of signal samples, wherein each sample corresponds to a different sampling time instant;

calculating a first value representing a logarithm of a quotient of a determinant of a trellis branch dependent covariance matrix of said signal samples and a determinant of a trellis branch dependent covariance matrix of a subset of said signal samples;

calculating a second value representing a quadratic of said signal samples less a plurality of target values normalized by a trellis branch dependent covariance of said signal samples;

calculating a third value representing a quadratic of a subset of said signal samples less a plurality of channel target values normalized by a trellis branch dependent covariance of said subset of signal samples;

calculating the branch weight from said first, second, and third values; and

“Signal-Dependent” Terms

- Marvell did not rebut Dr. McLaughlin’s discussion of the terms “media noise” and “signal-dependent”

26. More media noise is observed near transition regions of the recording layer than near non-transition regions. For that reason, media noise is considered to be pattern (or data or signal) dependent. In other words, the readback signal sample value for a transition (or non-transition) depends on the specific sequence of nearby transitions/non-transitions.

McLaughlin Declaration, 1/27/10, at pg. 9.

“Signal-Dependent” Terms

- Marvell’s construction merely reorders words in the claim term

DISPUTED CLAIM TERMS

Signal-Dependant Noise

’839 Patent Claims 2, 5 & ’180 Patent Claim 1

MARVELL’s PROPOSED CONSTRUCTION

“Signal-dependent noise” means

“noise that is **dependent** on the **signal.”**

  - Marvell’s proposed construction completely ignores the specification